

5. Human Health



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OVERVIEW

This chapter discusses human health risks associated with toxic and pathogenic contaminants in Puget Sound. Human health threats from Puget Sound occur primarily through consumption of shellfish and fish, rather than through direct contact with water. Since shellfish are predominantly filter feeders, they accumulate pathogens and toxic contaminants present in the water, which can become concentrated in the organism tissues. This poses a risk to humans when these organisms are harvested for consumption. Some of the key results in this chapter include:

- The Washington State Department of Health reclassified four commercial shellfish growing areas in Puget Sound in 1999, five areas in 2000 and six in 2001. A total of 1580 acres were upgraded and 2069 acres were downgraded over these three years.
- The number of confirmed cases of human *Vibrio parahaemolyticus* infection continued the declining trend with each consecutive year since a major outbreak occurred in 1997. There were six cases in 2001 compared to 66 in 1997.
- The state Department of Health observed the greatest concentration of paralytic shellfish poisoning (PSP) toxin in shellfish along the

Strait of Juan de Fuca and scattered sites in the Main Basin and south Puget Sound. Areas free of PSP in 2000 included Hood Canal south of Lofall, south Puget Sound west of Anderson Island, Saratoga Passage, and Westcott Bay on San Juan Island.

FINDINGS

Managing Risks from Shellfish Consumption Related to Pathogens

Washington State is among the top shellfish producing states in the nation. The state Department of Health, in collaboration with tribes and local health departments, maintains a classification system for shellfish growing areas and conducts sampling of shellfish meat to manage human health risks. These activities minimize direct exposure to pathogens (primarily bacteria) as well as exposure to biotoxins produced by non-pathogenic marine organisms.

Sanitation problems in areas that drain into shellfish-growing waters may contaminate shellfish with a number of pathogens. These potentially include bacteria that cause cholera, typhoid, dysentery and the virus that causes hepatitis A. The concentration of fecal coliform bacteria in marine water is used as an indicator of sanitation problems. The status and trend in fecal coliform observations are discussed in Chapter 3.

Commercial Growing Areas

The state Department of Health minimizes the risk of pathogen exposure associated with sanitation problems in commercial shellfish harvesting areas through classification of these areas. The classifications are based on evaluation of pollution sources and fecal coliform levels in marine water samples but may also reflect other factors such as presence of industrial contamination (e.g. metals, organic compounds). Commercial shellfish growing areas are classified as **Approved**, **Conditionally Approved**, **Restricted**, or **Prohibited**. These classes have specific standards derived from the National Shellfish Sanitation Program (NSSP) Model Ordinance. Areas that have not been surveyed and evaluated are included in the Prohibited class.

As of May 2001, the state Department of Health has classified nearly 200,000 acres in nearly 100 growing areas statewide as **Approved** or **Conditionally Approved** for shellfish harvest. In the 1980s, the state Department of Health downgraded almost 33,000 acres; only 1,000 acres were upgraded. However, in the 1990s, upgraded acreage nearly equaled downgraded acreage.

The NSSP guidelines ensure thorough assessment of fecal pollution conditions in shellfish harvest areas. Before an area is classified, the state Department of Health must collect at least 30 water samples from each sampling station in the growing area. While data are collected, a thorough sanitary survey must be done to locate and evaluate all potential pollution sources.

Two statistics are calculated from the 30 water samples. These are compared to the *NSSP Growing Area Criteria*. The criteria and their application are described below:

1. The *geometric mean* is not to exceed 14 MPN/100 ml water (applied in all cases).
2. The *90th percentile value* is not to exceed 43 MPN/100 ml water (applied to areas where only nonpoint sources are present:); or 10 percent of results are not to exceed 43 MPN/100 ml of water (applied when one or more point sources of pollution are present).

(Note: MPN means “most probable number” and represents a single fecal coliform bacterium.)

How shellfish growing areas are approved

To be **Approved** for harvest, a growing area must not only meet the NSSP water quality criteria, but a required shoreline survey must show no significant sources of fecal contamination. If the criteria are not met, but pollution events are shown to be episodic and predictable (e.g., rain-related runoff, etc.), an area may qualify as **Conditionally Approved**, i.e., harvest is allowed except during and immediately following the predictable pollution event. More data analysis is required to define the time limits of the conditional closure. To assure continued classification, sampling is continued and shoreline surveys are repeated periodically.

Growing Area	County	Year	Re-classification	Upgrade/ downgrade	Acres
Burley Lagoon	Pierce	1999	C → R	↓	210
		1999	P → R	↑	20
Port Gamble Bay	Kitsap	1999	P → A	↑	20
Portage Bay	Whatcom	1999	A → R	↓	90
Drayton Harbor	Whatcom	1999	A → P	↓	920
Sequim Bay	Clallam	2000	P → A	↑	750
Dungeness Bay	Clallam	2000	A → P	↓	300
Henderson Inlet	Thurston	2000	A → P	↓	8
Nisqually Reach	Thurston	2000	C → R	↓	74
		2000	C → A	↑	20
Similk Bay	Skagit	2000	A → P	↓	60
Duckabush	Jefferson	2001	R → A	↑	630
Dungeness Bay	Clallam	2001	A → P	↓	100
Henderson Inlet	Thurston	2001	A → C	↓	300
Burley Lagoon	Pierce	2001	R → A	↑	110
Filucy Bay	Pierce	2001	C → P	↓	7
Rocky Bay	Pierce	2001	P → A	↑	15

Table 5-1. Reclassifications of intertidal shellfish growing areas in 1999 and 2000.

A = Approved
C = Conditionally Approved
R = Restricted
P = Prohibited

Source: Washington State
Department of Health

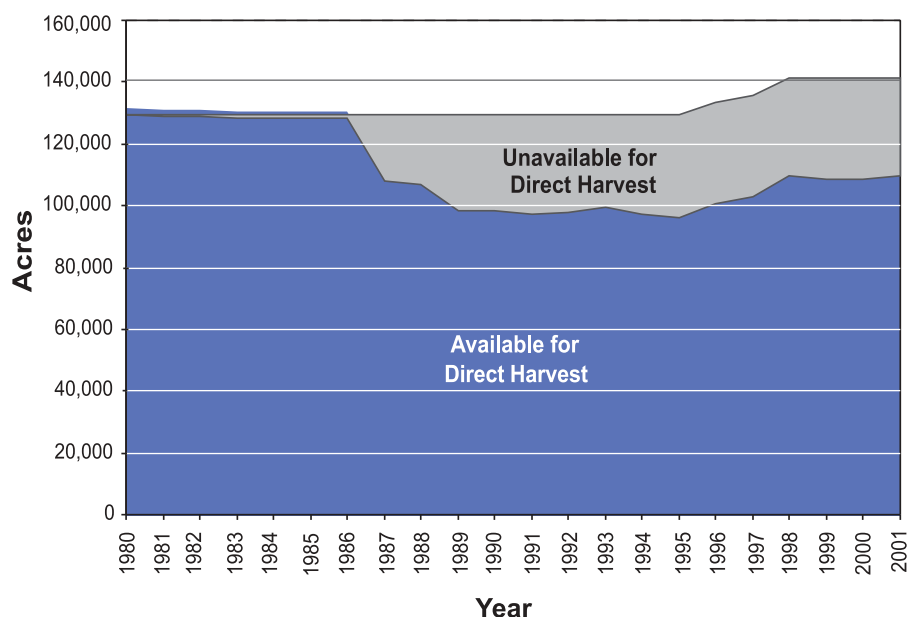


Figure 5-1. Trend in commercial shellfish growing areas in Puget Sound that are available (**Approved** and **Conditionally Approved**) and unavailable (**Restricted** and **Prohibited**) for harvest.

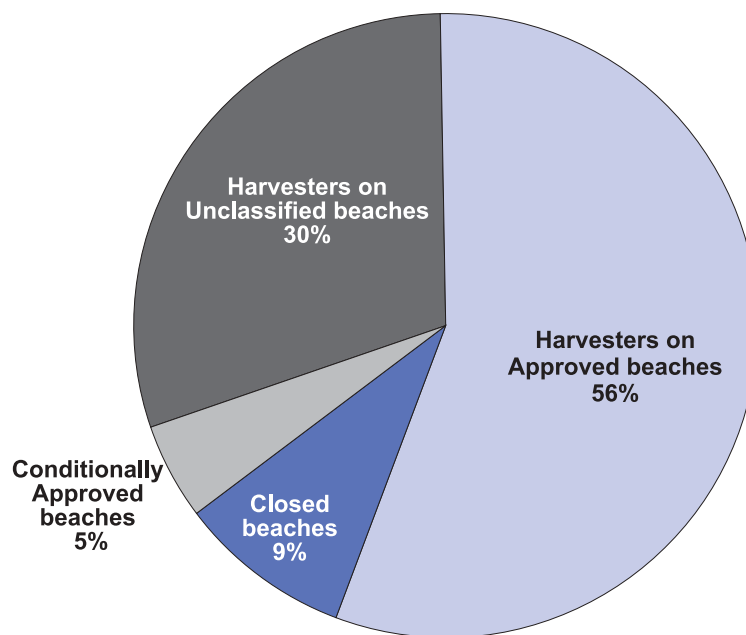
Source: Washington State
Department of Health

The state Department of Health provides an annual Early Warning list of threatened growing areas to shellfish growers and local and state agencies. An area is deemed threatened if the 90th percentile calculated for a station within the growing area exceeds 30 MPN per 100 ml. The 90th percentile is used because experience has shown that this statistic responds more quickly to change than does the geometric mean.

The state Department of Health reclassified four commercial shellfish growing areas in Puget Sound in 1999, five areas in 2000 and six in 2001. This does not include subtidal geoduck tracts. These reclassifications are shown in Table 5-1. Relative to larger reclassifications of the past 20 years (Figure 5-1), the changes in 1999 through 2001 involved relatively small areas. A total of 1,580 acres were upgraded and 2,069 acres were downgraded.

Figure 5-2. Breakdown of recreational shellfish harvesters in 2001 by the state Department of Health beach classification.

Source: Washington State Department of Health



Recreational Shellfish Harvest at Public Beaches

Local health jurisdictions and the state Department of Health shellfish programs work together to evaluate public beaches to determine which areas should be opened to recreational harvest and which areas should be closed. Recreational shellfish beaches are classified as **Approved**, **Conditional**, **Closed** or **Unclassified**.

The Washington State Department of Fish and Wildlife monitors the numbers of recreational shellfish harvesters on public beaches. The agency estimates that there were 189,000 harvesters in 2001, a 23 percent decrease relative to 2000. Figure 5-2 shows that the majority (56 percent) of recreational harvesters in 2001 harvested on beaches classified as open by the state Department of Health. Despite the efforts of the state Department of Health, 9 percent of recreational harvesters were observed on closed beaches and 30 percent on unclassified beaches.

Vibrio parahaemolyticus

The *Vibrio parahaemolyticus* bacterium occurs naturally and is common in marine and estuarine environments worldwide. It is considered an emerging, or spreading, pathogen in North America (McCarter 1999). The organism causes gastroenteritis in humans. In the summer of 1997, the largest reported outbreak of *V. parahaemolyticus* infections in North America occurred in the Pacific Northwest, primarily associated with the consumption of raw oysters that had accumulated the bacterium. One person died (CDC 1998).

Following the 1997 outbreak, the state Department of Health began regular monitoring of shellfish meat for *V. parahaemolyticus* (Table 5-2). Sale of oysters is restricted when the bacterium reaches 10,000 cfu (colony forming units) per gram of oyster tissue, but this restriction did not prevent the 1997 outbreak (CDC 1998).

There are more than 30 species of aquatic *Vibrio* bacteria. The species of greatest concern in Puget Sound is *V. parahaemolyticus*, particularly during warm water conditions in the summer. Prior to 1997, confirmed cases of *Vibrio* infection ranged from two to 32 per year. The numbers of infections have been declining since 1997 (Table 5-3).

Year	Growing Area	Maximum <i>Vibrio</i> concentration (cfu/gram)
1998	Totten Inlet - Oyster Bay	24,000
	Hood Canal North -Seabeck	> 1,100
	Hood Canal North - Quilcene	24,000
	Hood Canal North - Dabob Bay	4,270
	Case Inlet - Rocky Bay	2,400
	Eld Inlet	1,410
	Hood Canal South - Twanoh	2,050
1999	Hood Canal North - Quilcene	1,100
2000	Little Skookum	2,400
	Samish Bay	4,600
	Hood Canal North - Seabeck	1,100
2001	Eld Inlet	4,620

Year	Number of Cases
1997	66
1998	54
1999	17
2000	9
2001	6

There is a precedent for the successful control of a *Vibrio*—the virtual elimination of cholera, *V. cholerae*, from the U.S. The *Vibrio* group also includes *V. vulnificus* that can also infect humans from shellfish consumption but does not occur in Washington.

Biotoxins in Shellfish

Blooms of many phytoplankton species are a normal seasonal occurrence in Washington's inland marine waters. One dinoflagellate species, *Alexandrium catenella*, produces a toxin that causes paralytic shellfish poisoning (PSP). Shellfish filter the toxic algae out of the water while feeding and concentrate the toxin in their tissues. PSP toxin in shellfish is a serious threat to the health of shellfish consumers. Washington State has monitored PSP in shellfish since the 1930s. Monitoring was greatly expanded by the late 1950s, and now shellfish are monitored at hundreds of sites throughout Puget Sound and on the coast. In 1990, the state Department of Health set up a Sentinel Monitoring Program to provide systematic early warning of harmful levels of biotoxins. This year's *Update* reports on PSP from 34 Sentinel sites.

Another biotoxin, produced by diatoms in the genus *Pseudonitzschia*, causes amnesic shellfish poisoning (ASP) in humans, but these organisms are not found in Puget Sound and are not discussed here.

The state Department of Health scientists sorted all PSP results collected in 2000 into four categories based on PSP impact. The **PSP Impact Categories** are:

None: The PSP result was less than 80 µg per 100 grams of shellfish tissue (FDA action level).

Low: The PSP result ranged from 80-499 µg per 100 grams of shellfish tissue.

Table 5-2. Observations of *Vibrio parahaemolyticus* greater than 1,000 colony forming units (cfu) / gram since sampling began in 1997.

Source: Washington State Department of Health

Table 5-3. Number of confirmed cases of human *Vibrio parahaemolyticus* infection associated with the consumption of Washington shellfish, primarily oysters, or consumption of shellfish from multiple sources that include Washington State.

Source: Washington State Department of Health

Paralytic shellfish poison

PSP is actually a family of related chemicals called saxitoxins that interfere with nerve function in warm-blooded animals. The primary symptoms of PSP are numbness and tingling of the lips, tongue, face and extremities; difficulty talking, breathing and swallowing; loss of muscular coordination; and paralysis. PSP can lead to death if it paralyzes the respiratory system. Symptoms develop quickly, usually within an hour or two after eating PSP-contaminated shellfish. There is no known antidote.

Biotoxin Hotline

The Washington State Department of Health monitors biotoxin levels in shellfish throughout Washington's marine waters to protect shellfish consumers from biotoxin poisoning. When harmful levels of biotoxins are detected, the state Department of Health issues warnings to commercial shellfish growers, local health agencies, tribal resource agencies, and the public. Commercial harvest is stopped. Warnings are issued via newspapers, television, the Department of Health Biotoxin Hotline at (800) 562-5632, or by Internet (www.doh.wa.gov/ehp/sf/biotoxin.htm).

Moderate: The PSP level ranged from 500-999 µg per 100 grams of shellfish tissue.

High: The PSP level was greater than 1,000 µg per 100 grams of shellfish tissue.

Figure 5-3 depicts the proportion of PSP results falling within each PSP impact category during 2000 as a pie chart for each sentinel site. The greatest impact occurred along the Strait of Juan de Fuca and at scattered sites in the Main Basin and south Puget Sound. Areas free of PSP in 2000 included Hood Canal south of Lofall, south Puget Sound west of Anderson Island, Saratoga Passage, and Westcott Bay on San Juan Island (although free of PSP in year 2000, blooms occurred in 1997 through 1998 and 2001).

Figure 5-3 suggests that 21 of 34 Sentinel sites experienced **Low** to **High** PSP impact during 2000. The remaining 13 sites showed no significant impact. These sites were ranked by calculating an annual PSP impact factor. To calculate the factor for each site, the number of PSP results in each category was weighted according to PSP (i.e., the number of **Low** PSP results x 1, the number of **Moderate** PSP results x 2, the number of **High** PSP results x 3). The weighted categories were added to produce the impact factor for each sentinel site (Figure 5-3).

There is little evidence that PSP impact is related to human activity. Some sites with the highest impact factors (Figure 5-4) are located in rural areas with minimal to moderate human activity (Burley Lagoon, Discovery Bay, Drayton Harbor, Sequim and Filucy bays). On the other hand, some urbanized areas (Squalicum Harbor near Bellingham, Liberty Bay, and Sinclair Inlet) showed relatively low impact.

The onset, intensity, and duration of PSP episodes cannot yet be predicted due to the interaction of many poorly understood environmental factors. As a consequence, the state Department of Health will continue routine comprehensive monitoring of shellfish throughout Puget Sound.

Toxic Contaminants in Fish and Shellfish

Health Risk Assessments and Consumption Advisories for Puget Sound Fish

Scientists from the state Department of Health have identified nine fish and shellfish consumption advisories related to toxic chemical contamination in various locations around Puget Sound. These advisories are summarized in Table 5-4.

The state Department of Health scientists are currently evaluating fish contaminant data from PSAMP to assess human health risks from the consumption of Puget Sound fish. Assessments incorporate information on the toxicity of contaminants and estimates of fish consumption by various segments of the population. They also consider duration of exposure to the contaminants. Assessment of PCB exposure should be available in 2002.

The state Department of Health used its estimate of a tolerable daily intake (TDI) for methylmercury (Washington State Department of Health 1999) to assess exposure from consuming fish in Puget Sound. These analyses indicate that recreational anglers consuming freshwater species have exposure levels below the TDI, as do almost all recreational anglers consuming saltwater fish (Mariën and Patrick 2001). However, exposure analyses indicate that many within Native American populations exceed the TDI even though they consume fish with mercury concentrations comparable to "background" concentrations found in fish from open waters. The state Department of Health will update its TDI value as further data become available.

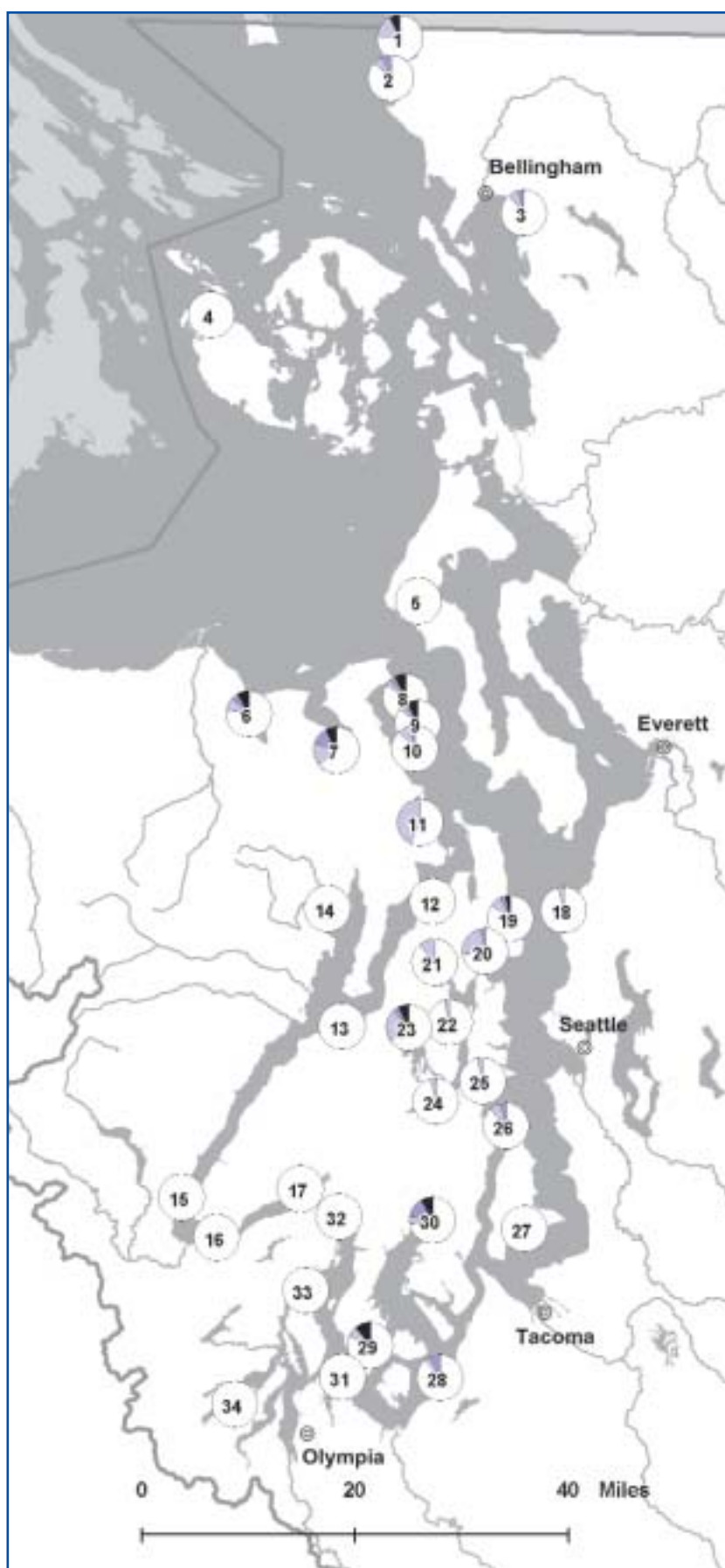
Effects of cooking shellfish

Cooking shellfish does not eliminate the toxin that causes paralytic shellfish poisoning (PSP). Cooking kills the organism, *Alexandrium catenella*, which produces the toxin, but the toxin remains.

Unlike PSP, vibriosis and the accompanying flu-like symptoms can be avoided by thoroughly cooking shellfish. This is especially important during summer months, when the bacteria that causes vibriosis, *Vibrio parahaemolyticus*, is more common.

Figure 5-3. Spatial distribution of PSP impact in Puget Sound in 2000.

Source: Washington State Department of Health



Sampling Sites:

1. Drayton Harbor
2. Birch Bay
3. Squalicum Harbor
4. Westcott Bay
5. Penn Cove
6. Sequim Bay State Park
7. Discovery Bay
8. Fort Flagler
9. Mystery Bay
10. Scow Bay
11. Port Ludlow
12. Lofall
13. Seabeck
14. Quilcene Bay
15. Hoodsport
16. Union
17. Lynch Cove
18. Edmonds
19. Kingston
20. Miller Bay
21. Liberty Bay
22. Port Orchard Passage
23. Dyes Inlet
24. Sinclair Inlet
25. Manchester
26. Southworth
27. Quartermaster Harbor
28. Steilacoom
29. Filucy Bay
30. Burley Lagoon
31. Johnson Point
32. North Bay
33. Jarrell Cove
34. Totten Inlet

Figure 5-4. Ranking of PSP-impacted sites in Puget Sound and the straits of Georgia and Juan de Fuca in 2000.

Source: Washington State Department of Health

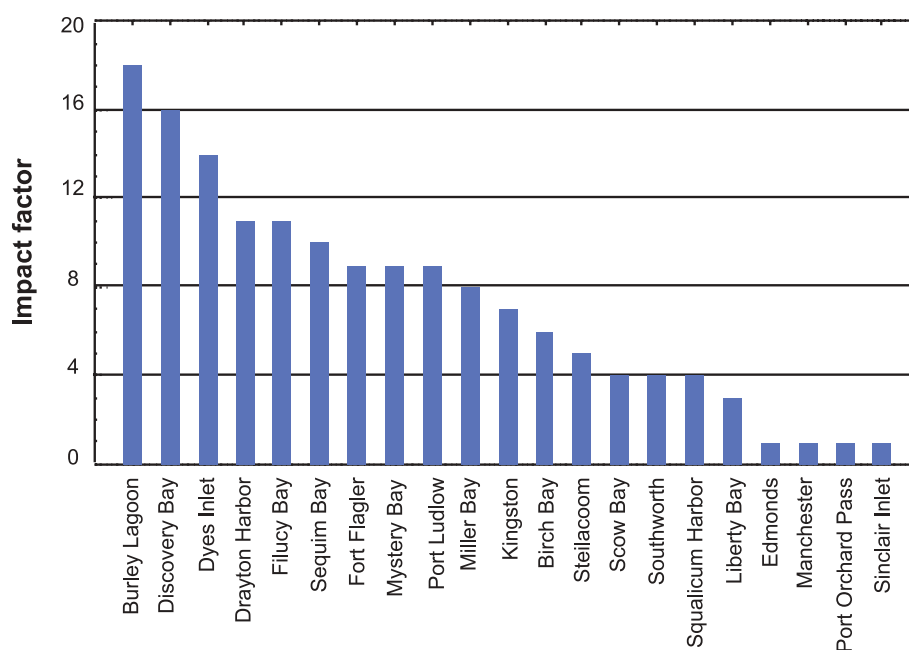


Table 5-4. 2001 Puget Sound fish and shellfish consumption advisories due to toxic chemical contamination.

Source: Washington State Department of Health

Location of advisory	Agency that issued advisory	Fish and shellfish affected	Contaminants identified
Budd Inlet, Olympia	Thurston County Health Dept.	Shellfish	Creosote, VOC, pentachlorophenol and dioxins
Commencement Bay, Tacoma	Tacoma-Pierce County Health Dept.	Bottom fish, shellfish and crab	PCBs and diethylphthalates, tetrachloroethylene, and metals
Dogfish Bay, Keyport	Bremerton-Kitsap County Health Dist.	Shellfish and bottom fish	metals and vinylchloride
Dyes Inlet, Bremerton	Bremerton-Kitsap County Health Dist.	Shellfish, bottom fish and crab	Naval ordnance
Eagle Harbor, Bainbridge Island	Bremerton-Kitsap County Health Dist.	Shellfish, bottom fish and crab	PAHs and mercury
Indian Island	US. Navy	Shellfish	Pesticides and metals
King County marine waters	Seattle-King County Dept. of Public Health	Shellfish, bottom fish, crab and seaweed	Contamination associated with historic industrial discharges
Manchester State Park, Port Orchard	Bremerton-Kitsap County Health Dist.	Shellfish	PCBs and dioxins
Sinclair Inlet, Bremerton	Bremerton-Kitsap County Health Dist.	Shellfish, crab, bottom fish	Mercury and PAHs

ACTING ON THE FINDINGS

The monitoring results discussed in this chapter suggest two recommendations for future studies and health management activities:

- Additional research is needed to understand the pattern and drivers that control the occurrence and spatial extent of PSP and *V. parahaemolyticus* shellfish contamination.
- The state Department of Health should provide information to help people manage human health risks associated with consuming Puget Sound fish. This should include state-issued fish consumption advice as the Department of Health has done for fish from Lake Whatcom, Lake Roosevelt and the Spokane River.

